Space Weather Technical Forecast

Issued on Tuesday, 12 March 2024 at 00:56 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Daily Chance of R1/R2, eventually reducing before UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity as recorded by GOES16 and 18 has reverted to Low, with isolated C-class activity recorded on a mid-B-class background. The peak of these flares was an impulsive C5.8 at 11/0850UTC from the largest and most complex group on the disc, AR3599. This sunspot group showed some development and spreading in its intermediate spots in the period, with penumbral area increasing. This was in addition to the maintained Mt Wilson delta spot in its leader.

AR3599 was one of four numbered groups on the disc, with a fifth un-numbered potential growing bipolar region gradually becoming visible in the northeast. This and the other numbered sunspot regions were unremarkable by contrast to AR3599.

There was some peripheral Coronal Mass Ejection (CME) activity seen in the period. These events included a coronal dimming from the northwest quadrant around 10/2300UTC, which was subsequently visible heading north and west of the Sun-Earth line to no effect. This was quickly followed by an apparent partial halo CME to the south and west - this second event appears to be related to far-side activity to no effect at Earth.

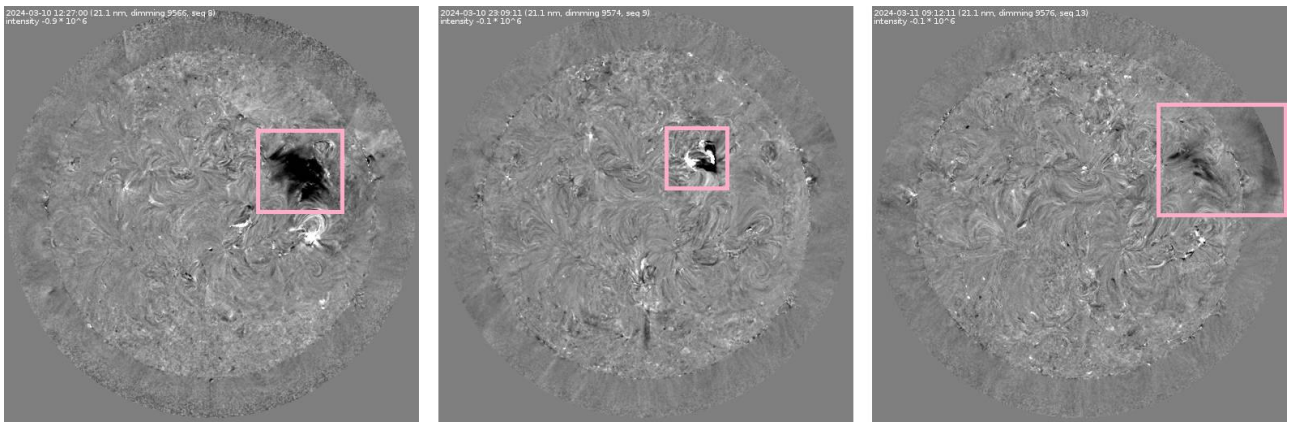

Figure 0: Trio of recent coronal dimmings, as processed by SIDC ROB. The first was tied to the M7.4 flare of 10 March and has a related CME which may deliver a glancing blow on 14 March. The later two dimmings are noted and are undergoing assessment as to any Earth-directed components of their associated CMEs.

A third event was associated with a Type II radio emission from the northwest quadrant, peaking 11/0853UTC, with an estimated speed of 489km/s. This event has yet to be modelled, but appears to far west to impinge on Earth. Finally, a prominence eruption from the southwest was emitted

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11/1230UTC. This event too has yet to be modelled but is likely to prove too far south and west of the Sun-Earth line to affect the forecast.

A faint CME emitted prior to this 24-hour window was tentatively associated with the 10/1215UTC M7.4 flare. This has now been analysed and may glance Earth later in the UTC day of Thursday 14 March to bring a Slight Chance of G1.

Solar Wind / Geomagnetic Activity: Solar wind speeds observed at L1 by ACE declined from Slightly Elevated levels to Background in the 24 hours, perhaps initially the tail of fast wind influence while the phi angle remained negative (i.e. towards the Sun - prior to 11/1130UTC), with a SSBC then occurring and the phi angle switching to positive.

The solar wind speed fell from 425km/s to 375km/s in the period, with the solar wind density at background single figures ppcc throughout. The IMF was stable and small-scale, at or below 6nT through the period, with a north-south component ranging between +5 and -4nT with an erratic character.

The net result of the above solar wind measures was provisionally Quiet to Unsettled, with the Unsettled peak occurring in the three-hour window containing the SSBC, with a Kp of 3-.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux remained very slightly elevated above resting background levels in the period in the wake of the M7.4 flare enhancement, albeit on a declining trend and with a peak below 0.4pfu.

High energy electron flux (greater than 2MeV) observed at GOES16 ranged between Moderate and High flux, with a peak of 1420pfu at 11/1605UTC. The observed 24-hour fluence showed a rising trend, with the 24-hour integrated fluence value at 12/0001UTC being 4.98e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of M-class flares from AR3599. This sunspot is expected to remain on the Earth-facing side until the end of the current UTC working week, whereupon the risk of Moderate activity should fall.

Solar Wind / Geomagnetic Activity: The 07 March CME has now most likely passed 1AU to no effect and is dropped from consideration. A CME associated with the M7.4 flare from 10 March may pass Earth as a glancing blow later in the UTC day of Thursday 14 March, giving a peak risk of a Slight Chance of G1 for the period as a whole.

Coronal hole fast wind activity is likely to be modest in the period, with a Chance of Active intervals should any belated entry into CH07/- occur in the first 24 hours. CH09/+ may then follow after midweek UTC, however this is likely to be weaker for being of the wrong polarity for the time of year for strong connection.
All considered, there is a Chance of Active intervals through the first three days of the period, perhaps culminating in a Slight Chance of G1 should the 10 March M7.4 CME materialise. Activity should be most reliably Quiet to round out the four-day period on Friday 15 March.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is expected to persist at background or close to background levels, with a very slight chance of S1 radiation storms, with the main risk from AR3599.

GOES16 high energy electron flux is likely to remain near its current diurnal Moderate to High oscillation in the near term, with electron counts perhaps reducing at GEO on the arrival of any 10 March CME around 14 March. There is a daily Slight Chance of Active fluence, probably peaking before midweek UTC prior to any CME influence.

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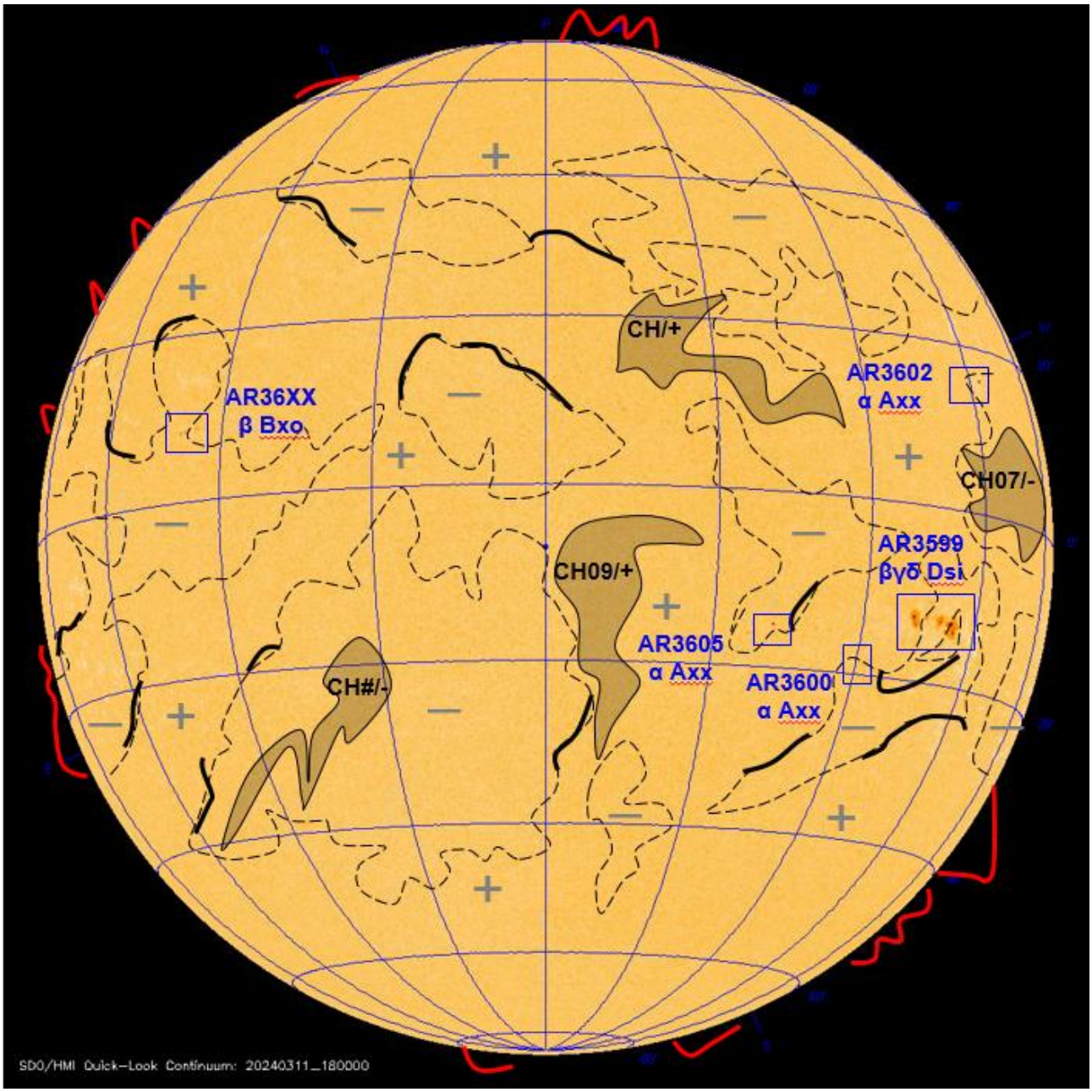
Figure 1. Solar Analysis Valid 11/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The previously-advertised CME from 07 March was due nearly 24 hours ago and is now dropped from further consideration. It is possible that an enhancement of ACE EPAM LEMS seen through the early hours UTC in low energies may have been a close pass of this feature, else this may have been tied to the slight high-energy proton enhancement that preceded this and was related to the M7.4 flare from AR3599 on 10 March.

Removal of the above from consideration leaves one CME in the forecast, a potential glancing blow from the M7.4 CME of 10 March, with this signalled to pass largely above and ahead of the track of the Earth in its orbit on Thursday 14 March. MOSWOC Enlil and its ensemble suggest there is nevertheless a Slight Chance of glancing incidence later in the UTC day of 14 March, albit with low confidence.

The fast wind aspect of the forecast is also of relatively low confidence, with none of the current cohort of coronal holes particularly well-formed or having strong links to previous incarnations on last rotation. CH06 has now decidedly finished with the SSBC of 11/1130UTC, leaving CH07/- as overdue but perhaps delivering a Chance of Active intervals in the first 24 hours. A second coronal hole nearer the middle of the current disc is also relatively uncertain in terms of any effects, with CH09's positive polarity not lending itself to strong connection given the time of year. This feature will probably connect shortly after midweek UTC, but again with limited effects.

All considered, perhaps the most reliably Quiet day is expected to be Friday 15 March, with minor coronal hole influence possible before this, and perhaps a Slight Chance of Minor Geomagnetic Storm G1 peaking on Thursday 14 March should the 10 March M7.4 CME materialise.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	1	1	10	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0145UTC	Partial	Following M7.4 from AR3599	NW quadrant	300	14/1200UTC	Glancing incidence, low confidence.

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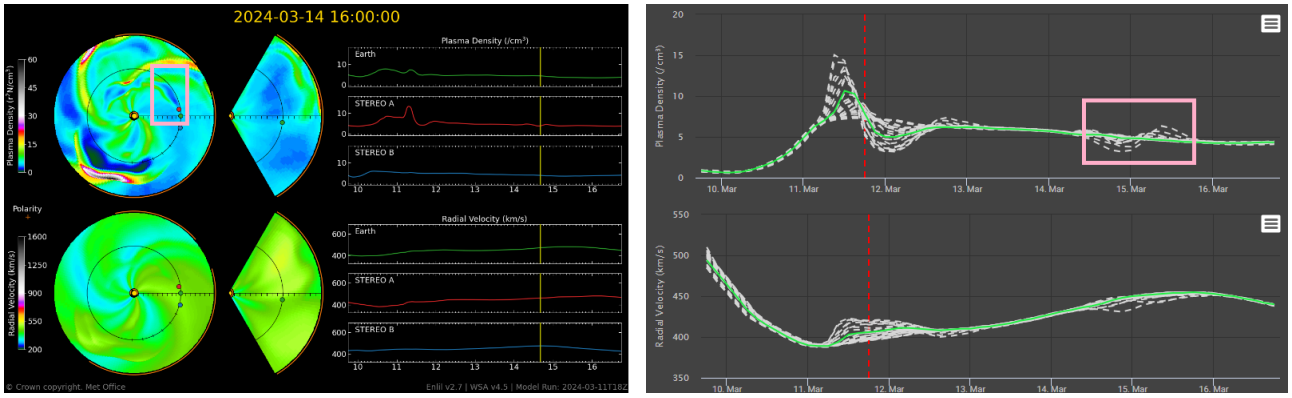
Figure 2: Latest MOSWOC Enlil run (badge time 11/1800UTC), paused at 1AU crossing time of M7.4-associated CME, which is expected to pass largely north and west of the Sun-Earth line. The deterministic run is largely a miss, with a few ensemble members suggesting narrow glancing blows on or after 14/1200UTC.



Radio Blackouts - X-Ray Flares:

The current Earth-facing disc is dominated by AR3599, and activity and flare probabilities are strongly tied to the evolution of this sunspot region. Recent trends in the group appear to be of proliferation and spreading in its central spots, as well as an increase in penumbral area. While this has yet to result in significant flares in the past 36 hours, this is a worsening tendency, and the daily probabilities of M-class and X-class flares are held a little higher than the raw values for a Dsi/BGD would suggest. The main feature of the X-ray flare forecast in the coming four days is the eventual passing of this sunspot group on the far side, with this thought to occur on Friday 15 March and accompanied by a corresponding fall in flare risk on this UTC day. No significant returning regions are expected to slow or reverse this trend.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	25	25	25	20
Very Active	R3 to R5 X Class	No	5	5	5	1

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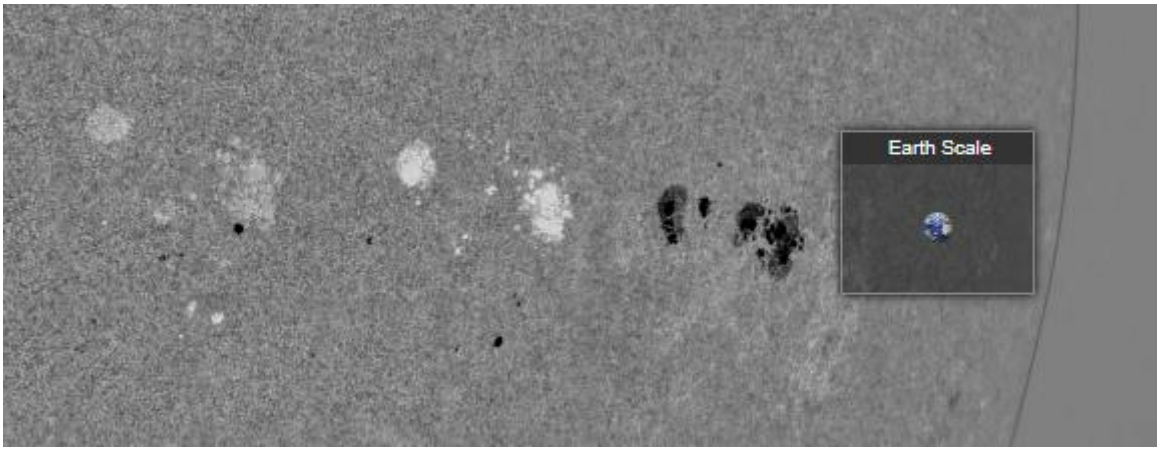
Figure 3: Helioviewer.org-generated HMIIF difference imagery of AR3599 in the southwest quadrant, with the solar limb and Earth shown for scale. Image validity times are 11/2300UTC for the black footprint, and 10/2300 and 09/2300UTC for the more eastward white footprints. Note the relative increase in area and spot count – this is in part the rationale for maintaining the daily chance of M-class activity above raw values for a Dsi/BGD.



Solar Radiation Storms - (High Energy Protons):

GOES18 proton flux levels are very closely tied to developments in AR3599, with no other sunspot groups of note. This feature proved capable of delivering at least a modicum of an enhancement at GOES18 on 10 March in the wake of the M7.4 flare. The risk of S1+ therefore increases very slightly through the period as AR3599 advances to the western limb and slightly beyond in the coming four days, probably then very gradually reducing over the coming UTC weekend.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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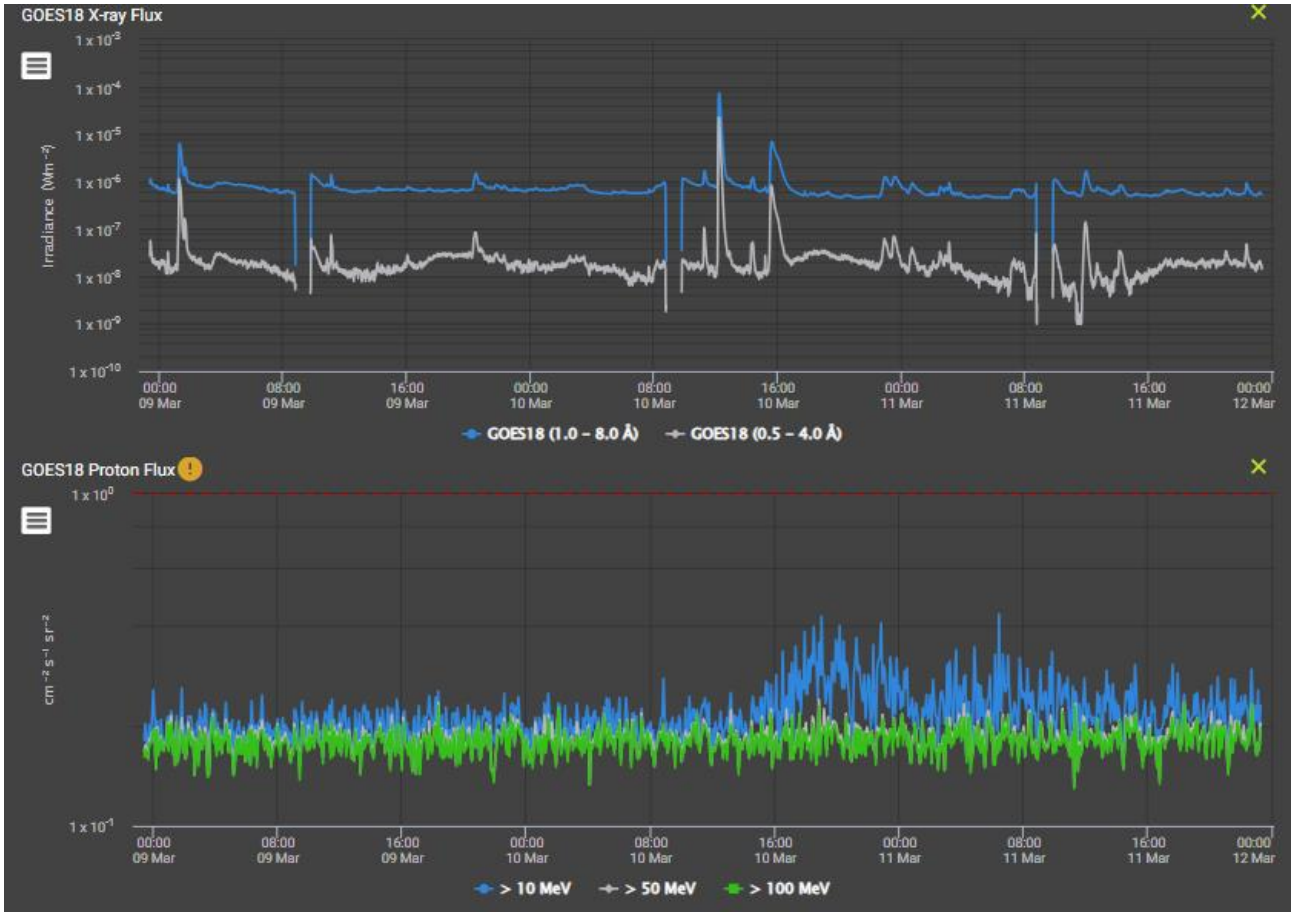
Figure 4: Past 72 hours in GOES18 X-ray flux, with resultant high energy proton flux showing a delayed response to the M7.4 flare on 10 March from AR3599.



High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has shown a slight reaction to the recent CH06/-fast wind in flux levels rising from Normal Background to eventually exceed High in the past UTC day. While it is still possible that this enhancement has yet to fully mature, in all likelihood current levels are probably near equilibrium and 24-hour integrated fluence may well fall a little short of Active. The probabilities of exceedence probably peak prior to midweek UTC and any CME influence from the 10 March M7.4, with a slight reduction possible to see out the working week.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	20	20	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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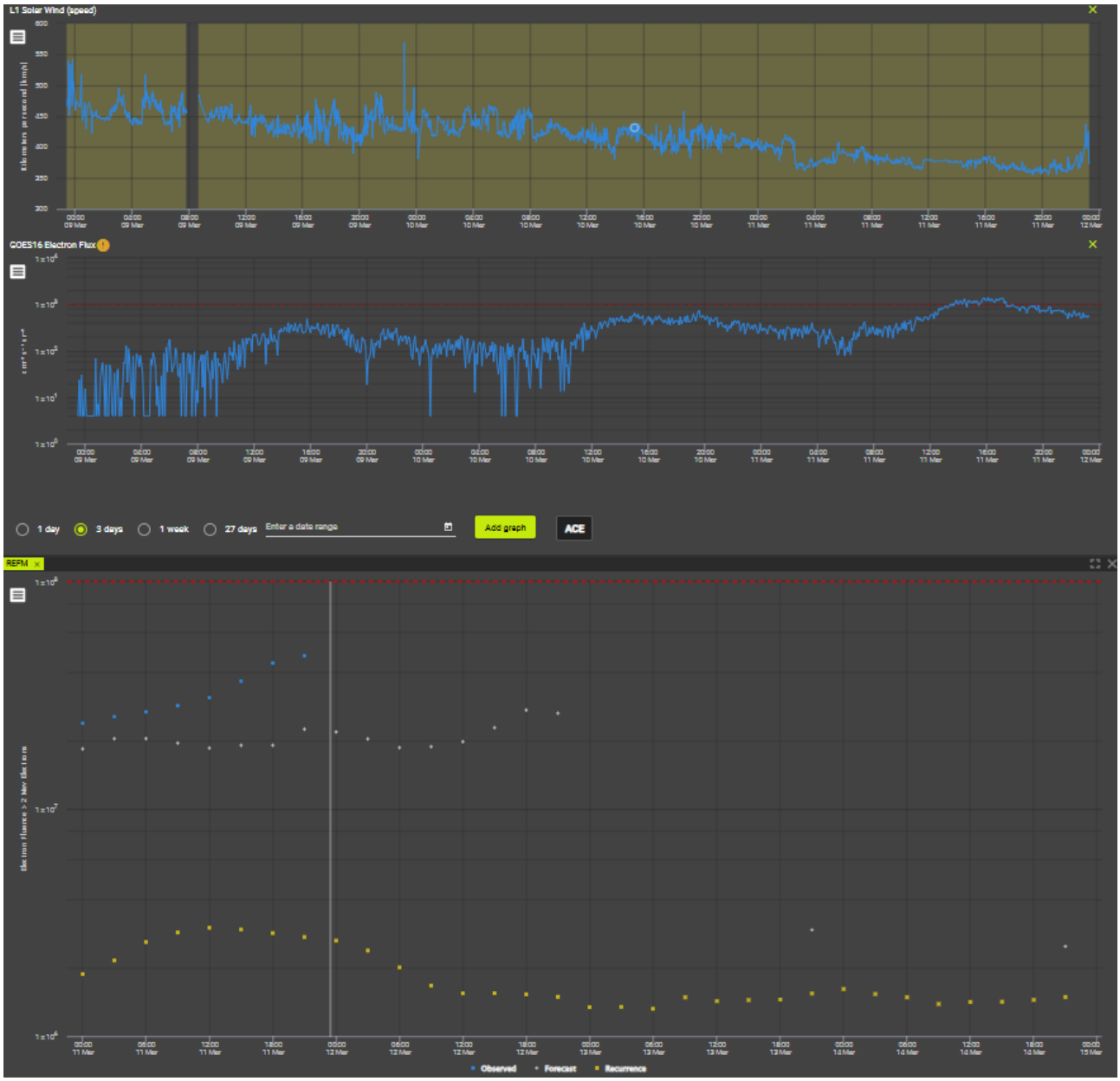
Figure 5: L1 solar wind speed as recorded at ACE, showing weakening connection to CH06's fast wind, with resultant GOES16 high energy electrons at GEO rising as geomagnetic activity wanes. The latest MOSWOC REFM forecast can be seen to be damped by previous passes, but is likely correct in maintaining levels below Active, with counts at GEO now plataeuing.



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